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THE INFLUENCE OF GEOMETRICAL PARAMETERS AND TRAFFIC COMPOSITION OVER THE AIR POLLUTION IN URBAN AREAS

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Abstract: Brasov is in constant transformation. Since 2007, a number of intersections have been structurally modified. Also in 2009 the city beltway was put into use. This paper aims to analyze the level of air pollution according to the geometrical parameters of intersections and traffic composition. This study is a comparison between the values of the main pollutants from motor vehicles, registered at an intersection, in three different periods (in years 2007, 2009 and 2011). Analyzing the registered values can be said that the main contributor to air pollution is the traffic composition. It is essential that the heavy vehicles number present in the traffic flow to be minimized. Transforming the intersection from the traffic lights intersection in roundabouts has little effect on the air pollution in urban areas.

1. INTRODUCTION

As a result of demographic, economic, land use and international developments, mobility is still increasing. Mobility is a necessary condition for economic growth and social development. However, this increase in mobility also has negative side-effects, such as congestion and air pollution. In order to facilitate mobility whilst minimizing its negative side effects, various measures can be employed, for instance the construction of new infrastructure, traffic management measures (e.g. ramp metering, route guidance), land use policy (e.g. compact city) and measures that try to influence travel behavior (e.g. road pricing).

Air pollution in Brasov County is on one hand generated by the fact that Brasov represents a central point of Romania's transport system with oncoming and going heavy traffic; and on the other hand pollutants are generated by stationary sources such as individual heating apparatus and diverse production processes of goods and materials.

The traffic results in gaseous and solid pollutants released into the atmosphere, of which the most notable are: Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitrogen Oxide (NO_x), Volatile Organic Compounds (VOC), Sulphur Dioxide (SO_2). Once released into the atmosphere, depending on the current meteorological conditions, these pollutants partake in photochemical reactions, which contribute to photochemical smog formation, resulting in pulmonary condition and respiratory blockage. The concentration of these pollutants is directly linked to: traffic intensity and vehicle type, number and frequencies of stops, terrain configuration, prevailing winds, height and dispersion of surrounding buildings, meteorological conditions which contribute to pollutant scatter [1,4].

2. THE ANALYZED AREA

Because of its geographical positioning, Brasov has always been a major intersection of the main routes in the area, linking the Transylvanian, Muntenian and Moldavian regions. Therefore, Brasov has developed in time as a major industrial and commercial hub, being one of the first settlements in Transylvania, with a history that starts before the year 1203.

A major influence of the urban area pollution in today's Brasov, is the geographical layout of the city. Starting as a medieval town, Brasov was strategically positioned between mountains. It was surrounded by Tampa Mountain at S and S-E, and by the foot of the Postavaru Mountain at S-V, V and N-V, having the 1799m high Postavaru Peak not further from 10 km away. Although this had proven to be a great way of defending the town from conquerors, nowadays, when the pollution factor is very important for every city, this geographical layout acts against Brasov.

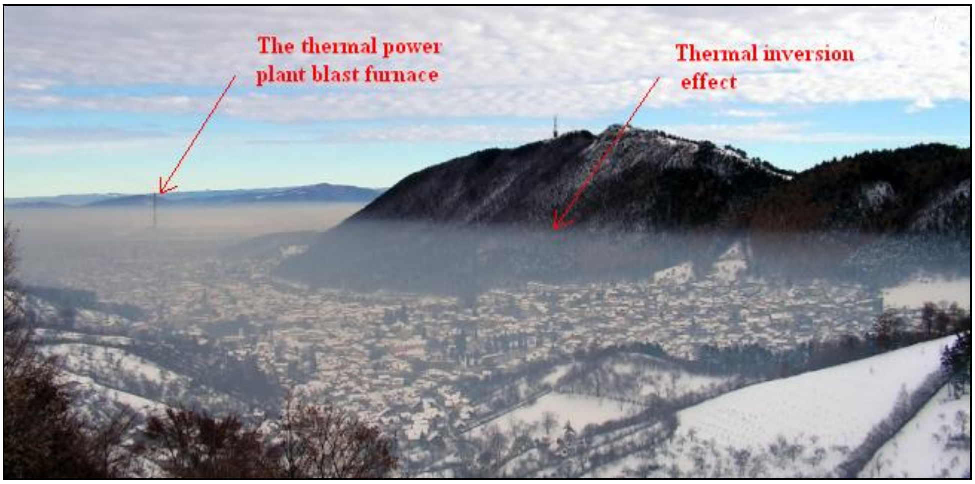

Fig. 1. The Brasov city air pollution.

The city had developed from the old town, but still, being so close to the mountain surroundings, Brasov city is in a depression area. This leads to thermal inversion effect, that makes the urban emissions to be trapped close to the ground and fresh air is blocked from draining the urban area [2,3].

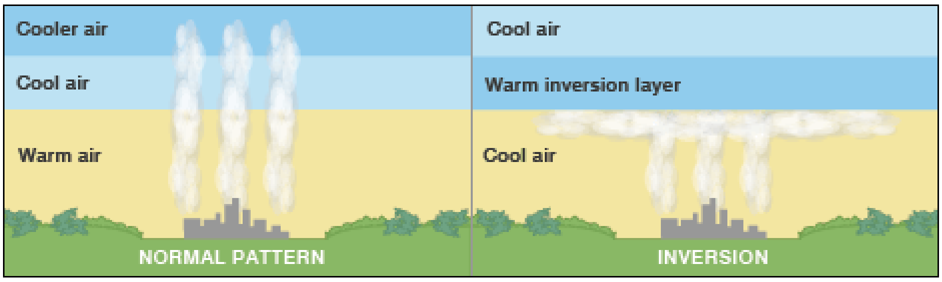

Fig. 2. The thermal inversion effect.

Although there is no real solution for this phenomenon when we consider the urban traffic emissions, this helps us understand better the importance of the fossil fuel emissions in our city.

The intersection Gării Avenue with Victoriei Avenue is one of the city's intersections with the most abundant traffic flow. Being near the center of the city, and most importantly being the entrance/exit intersection of the city train station, it is obvious that is a major link in Brasov's infrastructure. Therefore, the trolleybus line, numerous bus lines, taxi cabs, public transportation with short, medium and long route busses and minivans, supply trucks and minivans, and last but not least private vehicles, they are all passing trough this very intersection in a very weigh number.

The traffic speed limit for the each of the arteries of this intersection is 60 km/h. Prevailing vehicle type that transit the intersection:

- Compression ignition engine vehicles and spark ignition engine vehicles;
- The public transportation vehicles with articulated and unarticulated buses and articulated trolleybuses.

- Traffic intensity at rush hour: very high.

Fig. 3. Aerial view of the studied intersection.

As part of the metropolitan road infrastructure expansion during the course of 2008, another branch of the city bypass went into service. The new city bypass diverts heavy traffic away from the city center at a rate of about 10000 vehicles per day.

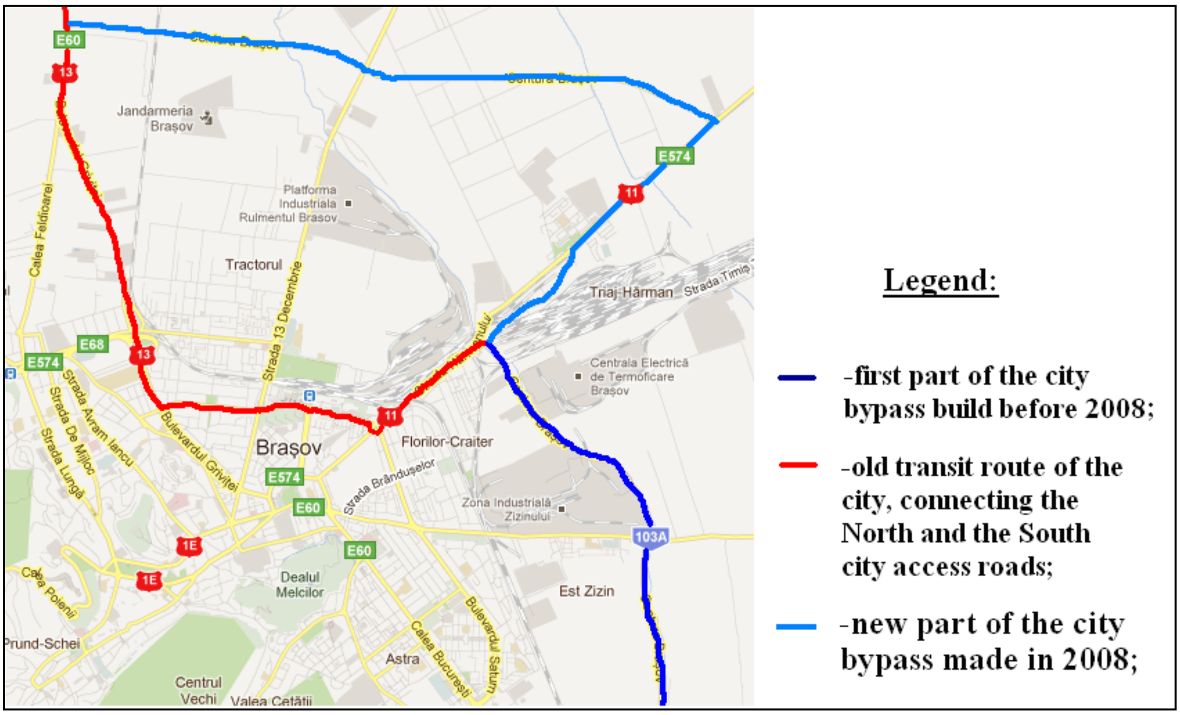

Fig. 4. Map of the city semi – bypass road.

The figure 4 presents the old transit route of the city, before the city bypass was complete. The traffic transiting the city from North to South and vice versa, mainly composed of heavy vehicles was passing through a considerable part of the city. In this figure it can be seen that this intersection was a main link of this route [6].

The traffic emissions are lowered in average in this junction as a result of the heavy traffic restriction inside the urban area of the city and the vehicle fleet renewal process. In the 2009 study a flow of 5289 vehicles was recorded crossing this intersection in one hour lapse, of which 9.4% were heavy vehicles, while in the 2011 study a flow of 3665 vehicles was recorded crossing the junction in one hour lapse, of which just 1.4% were heavy vehicles.

The 2009 pollution emission study for this intersection was made in similar weather conditions with the one in 2011. The time interval and the intersection structure were the same in both studies.

3. THE AIR POLLUTION AND METEOROLOGICAL MEASUREMENTS

The MultiRAE IR Model PGM-54 (is a programmable multiple-gas monitor designed to provide continuous exposure monitoring of toxic organic and inorganic gases, oxygen and combustible gases. The monitor can be used as a personal monitor, a hand-held sniffer, or as a continuous operational area monitor. This device is equipped with four sensor cells and it can detect the concentration of four different gasses simultaneously. The targeted emission gasses were: carbon monoxide, volatile organic compounds, sulfur dioxide. The measurements have been made considering the gas analyzing standards SR EN ISO 16664:2009. The measuring points for the emission levels have been chosen in regard to the known factors of influence: composition and size of the flow of vehicles passing through the junction; engine operating conditions when passing through intersections; climatic conditions in the measuring interval.

The Airflow Model TA460 is a portable, hand held, multi-function thermal anemometer. It is designed to measure air velocity, differential pressure, temperature, and humidity. Calculations include air flow, wet bulb, dew point, and turbulence. With the optional probes, measurements include air velocity, temperature, humidity, pressure, CO and CO_2.

4. INTERSECTION ANALYZES IN FUNCTION OF GEOMETRICAL PARAMETERS AND TRAFFIC FLOW COMPOSITION

In the studied intersection since 2007, every year air pollution measurements were made. The measuring points and hour interval were the same, with little positioning changes imposed by the geometrical parameters. In the year of 2007 occurred the first modification of the intersection, by removing the trams from the city. In 2009 the intersection was transformed from a traffic light intersection in roundabout intersection. Also, in 2010 the Brasov bypass road was finalized and the heavy traffic was completely removed from the city. In these conditions we chose to compare air pollution measurements made in 2007, 2009 and 2011. The difference between the 2007 and 2009 configurations of the intersection is mainly given by the road infrastructure (changing the geometric parameters of the intersection). Analyzing the 2009 and 2011 configurations of the intersection it can be noticed that the main change is the road traffic flow (significant decrease of the heavy vehicles number).

Figure 5 presents the intersection schemes in the years 2007, 2009 and 2011, which shows the changes of geometrical parameters from 2007 to present.

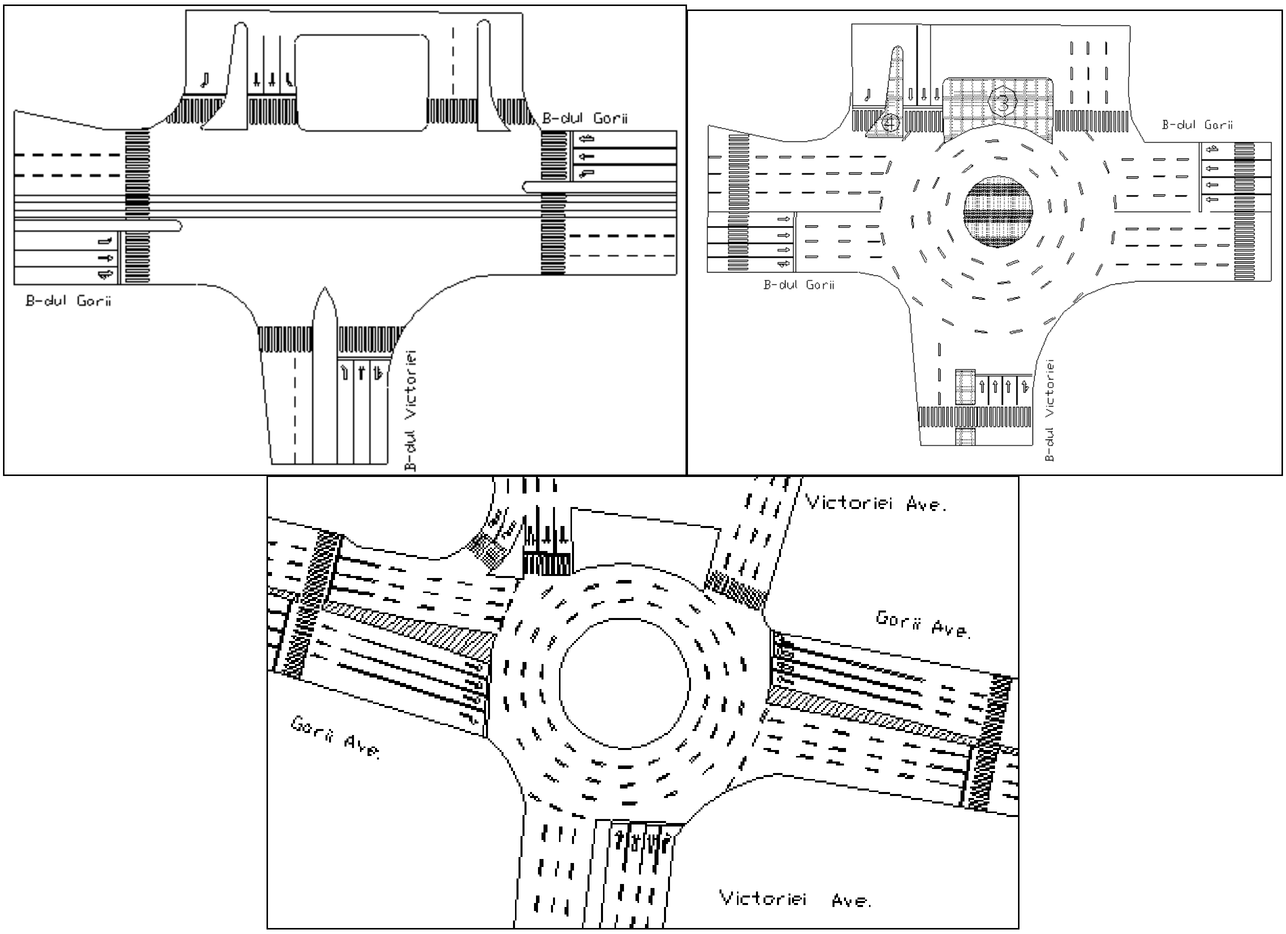

Fig. 5. Intersection layout in 2007 (left), 2009 (right) and 2011 (down).

In Figure 6 are presented the points where measurements were made. In this 12 points were made air pollution measurements with MultiRAE IR portable analyzer and in the T1, T2, T3 and T4 points were collected weather data, using Airflow TA460 anemometer.

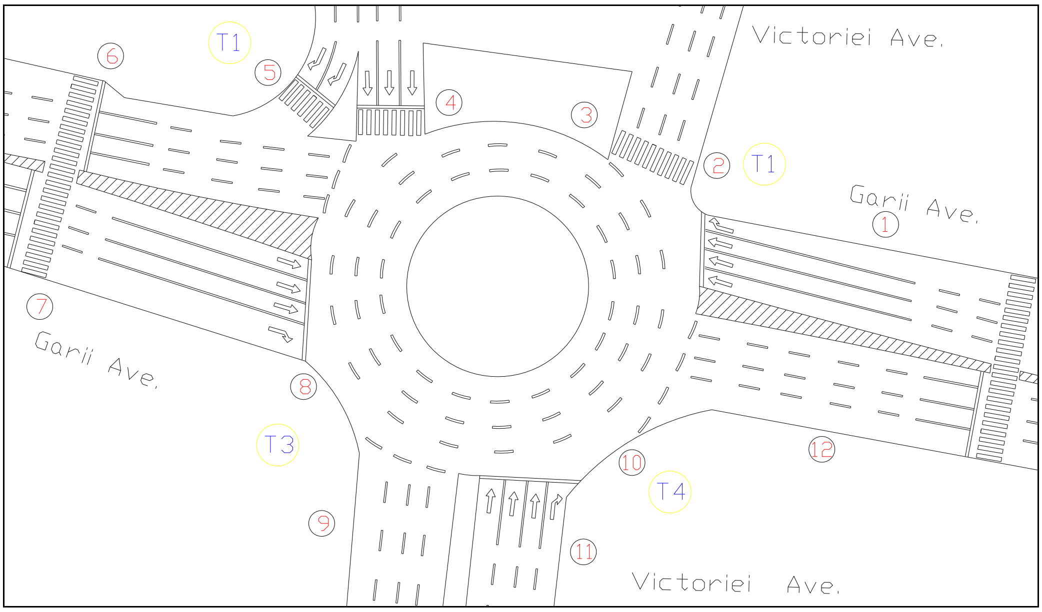

Fig. 6. Measurement points (1-10: air pollution; T1-T4: meteorological conditions).

After the measurements, results values of the main pollutants from the burning of fossil fuels used by vehicles and values representing the weather conditions. These data are presented in the following tables, exemplifying with the 2011 measurements.

Table 1 - The MultiRAE IR gas detector readings

Measurement point:	Date and Time:	CO [ppm]	VOC [ppm]	SO_2 [ppm]	CO_2 [ppm]
1.	25/05/2011 15:00	1.1	1.7	0.1	960
2.	25/05/2011 15:05	1.4	0.9	0.0	1020
3.	25/05/2011 15:11	1.5	2.1	0.0	960
4.	25/05/2011 15:17	1.1	2.7	0.0	1000
5.	25/05/2011 15:22	1.0	1.4	0.0	680
6.	25/05/2011 15:29	1.1	1.2	0.0	630
7.	25/05/2011 15:35	1.2	2.0	0.1	730
8.	25/05/2011 15:41	1.2	1.9	0.0	690
9.	25/05/2011 15:47	1.6	2.7	0.1	610
10.	25/05/2011 15:53	1.8	0.8	0.2	900
11.	25/05/2011 15:59	1.1	1.3	0.1	630
12.	25/05/2011 16:05	1.4	1.9	0.0	710
Average:		1.3	1.7	>0.1	797

Table 2 - The Airflow TA460 data

Channel:	Velocity:	Flow:	T:	Relative Humidity:	Barometric Pressure:
Units:	m/s	m^3/h	°C	%rh	mmHg
Average:	0.8	290	27.9	34.3	716.7
Minimum:	0.0	0.0	25.2	30.1	716.5
Maximum:	1.0	694.2	31.2	38.3	716.9

Traffic flows data recorded in 2007, 2009 and 2011 are presented in the following table:

Table 3 – Traffic flow composition variation in time

Year	Passenger vehicle:	Unarticulated bus:	Articulated bus:	Trolleybus:	Heavy vehicles:	Trams:	Total number of vehicles:
2007	2993	93	19	13	302	18	3438
2009	3162	97	20	16	319	0	3616
2011	3454	123	16	20	52	0	3665

To make a comparison between the values recorded from all three measurements, the values collected were centralized and the following charts result:

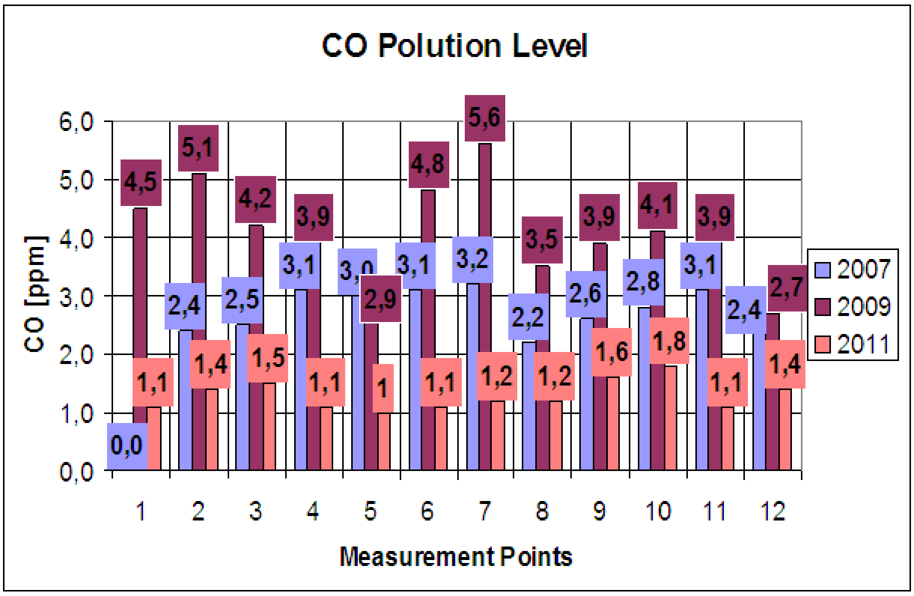

Fig. 7. CO registered values for all 12 measurement points.

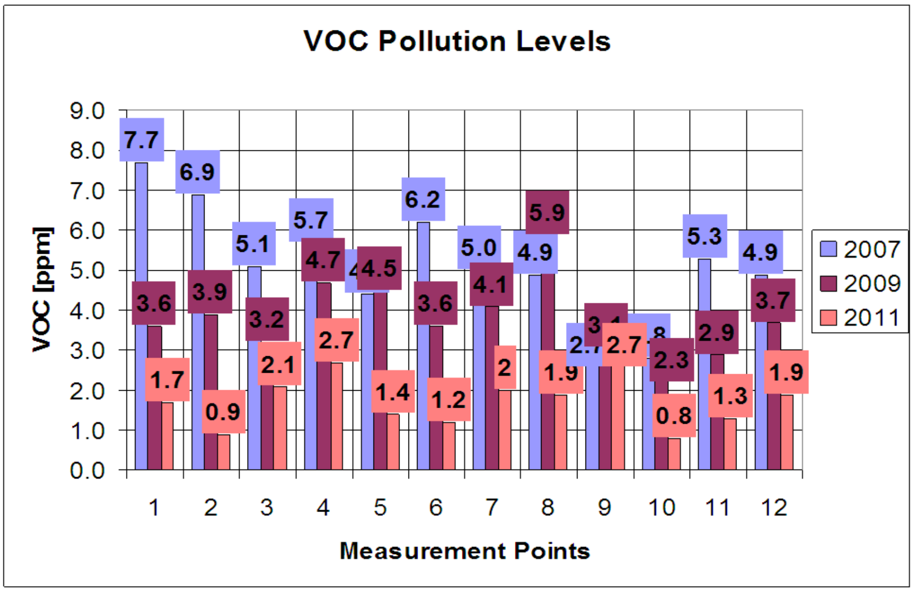

Fig. 8. VCO registered values for all 12 measurement points.

Analyzing the carbon monoxide, the highest values were recorded in 2009, when the only modification of the intersection was his geometric parameters. In 2011 the registered CO values was minimal, as a heavy traffic elimination consequence.

The highest VOC values were recorded in 2007. The main factors of this high level of pollution are: traffic composition, age of fleet vehicles and concentrating many vehicles on the lanes at traffic lights. The level of volatile organic compounds decreased with the elimination of these factors, culminating with the opening of the bypass road.

The sulfur dioxide is relatively high in 2007 and 2009 intersection configurations. After the substantial decrease of the heavy vehicles number, SO_2 values tend to a minimum. Sulphur dioxide is generally specific to the Diesel vehicles engines and particularly to the heavy vehicles.

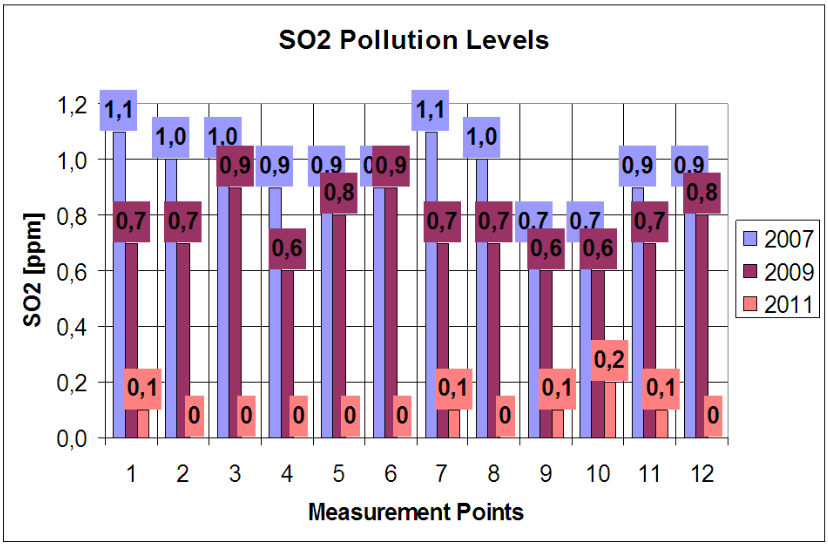

Fig. 9. SO_2 registered values for all 12 measurement points.

Analyzing the registered values can be said that the main contributor to air pollution is the traffic composition. It is essential that the heavy vehicles number present in the traffic flow to be minimized. Transforming the intersection from the traffic lights intersection in roundabouts has little effect on the air pollution in urban areas.

If for a traffic light intersection, the main pollutant concentrations suffer variations between measurement points, for a roundabout pollutant values are lower, but there is uniformity throughout the entire area.

5. CONCLUSIONS

From this study which as realized on the base of the data obtained experimentally can be observed some characteristics of the pollution made by traffic flow:

• Overall lower emission values were recorded due to continuous improvements to the intersection layout; redesigning the intersection into a roundabout type has homogenized the traffic flow and pollutant levels.

• Overall fuel pollutants were recorded in certain points due to the change in traffic composition; a further reduction in pollution was generated by the opening of the city bypass in 2008 therefore the heavy traffic was rerouted avoiding the city center.

• Pedestrian flow was not impeded due to the relocation of the crosswalks further away from the center of the intersection.

• Modernization of passenger vehicle fleet along with stricter European emission laws has played an important role in combating pollution in urban areas.

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